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ON WATER SUPPLY TO GREAT TOWNS: *Its Extent, Cost, Uses, and Abuses.* By JOHN STRANG, LL.D., *City Chamberlain, Glasgow.*

[Read before Section (F), Economic Science and Statistics, of the British Association for the Advancement of Science, at Leeds, 23rd September, 1858.]

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FROM the peculiar constitution of man, it need scarcely be stated that Water has necessarily been to him an object of primary importance. From the earliest records and monuments we find, wherever human beings happened to be congregated, that this primary element of their existence became an object of chief attention, and that it was only where this great desideratum was abundant, that masses of mankind were found to exist. It followed, therefore, wherever cities were not established on the banks of pellucid streams, but on the sides of rivers, the purity of which had become inappropriate for domestic uses, that artificial means were adopted to furnish what was requisite for the use and comfort of the inhabitants. Amid the ruins of Eastern grandeur, and the still remaining aqueducts of Rome and other cities of the West, abundant evidences still exist of the anxiety manifested for supplying water for their inmates, and for the embellishment, through monumental fountains, of the cities themselves. In modern times, an abundant and pure supply of water for the great and growing cities of the world, has been a peculiar characteristic of legislation and enterprise; and in our own days, Waterworks upon the most gigantic scale have been completed, are in progress, or are projected, to minister to all the exigencies which advanced civilisation, modern comfort, and increasing luxury may require. Let us endeavour to show, by a few statistical facts, derived from the best and most authentic sources, the present and projected water supply of a few of the leading capitals of the Western world, with the extent and cost of such supply, and with some of the social advantages, and even evils, which have arisen, or may still further arise, from rendering water the too easy agent for the removal of impurities which should be transported otherwise,

and thus converting many once pellucid streams, upon which so many cities are founded, into deleterious and noxious common sewers, detrimental to comfort and hostile to health.

We shall begin with

London,

which is at present supplied with water by ten independent Companies. The chief sources of supply are from the River Thames and the River Lea—five of the companies, with a daily supply of 35,372,782 gallons, being furnished by the former, while two companies, with a daily supply of 41,000,000 of gallons, is furnished by the latter. The remaining three companies, with a supply of 4,653,000 gallons, are taken from the River Ravensbourne and the ponds and chalk wells of Hampstead, Plumstead, and Woolwich. The great power employed for its distribution, is steam applied to pumping, amounting to a nominal power of 7,254 horses. The length of the mains and branches extend to 2,086 miles. The area of subsiding reservoirs extend to 141 acres, and of filter beds to 40 acres. The number of Houses supplied amounts to 328,561, and the gross quantity supplied per day reaches 81,025,842 gallons. The entire cost of the several works in the year 1856 was 7,102,823*l.*, which shows that for every pound expended there is a daily supply of 11·4 gallons.

Few cities have improved their water supply in the course of a few years more than London, both in quantity and quality. In 1850 the whole number of Houses supplied was only 270,581, whereas in 1856 water was furnished to 328,561 of the 340,000 houses which now form the aggregate within the Registrar-General's district; while the daily supply of water for all purposes, which in 1850 was 160 gallons per house, was in 1856 no less than 246 gallons. In 1857 the whole population within the bounds of supply amounted to 2,667,617, which leaves, after deducting one-sixth for trade purposes, 26·3 gallons for every individual. Previous to the passing of the Metropolis Water Act of 1852, considerably more than half of the supply was not filtered, the impurities in suspension being only cleared by subsiding reservoirs. Now, however, an area of no less than 40 acres of filters has been added to these subsiding reservoirs. According to the chemical report of Messrs. Hoffman and Blyth, the waters now supplied to the whole metropolis contained not more than *one-half* of the organic matter which was present in these during the year 1851—a diminution of organic matter which, it appears, is neither due to the influence of the season, nor to any difference in the mode of determining its quality in 1851 and 1856, but solely to the alteration of the localities from which many of the companies derive their present supply, and to the manifest improve-

ment which has taken place, in the collection, filtration, and general management of the supply of the metropolis. It has been stated by the Board of Health Inspectors, that the various Companies have more than complied with the obligations placed upon them by the last Parliamentary Act, and have evinced a most anxious desire to discharge the duties imposed upon them for the public good. The only difficulty experienced in drawing supplies from such rivers as the Thames and Lea, arises from the increased and increasing drainage operations pursued by the towns and villages situated on their banks, which, by discharging therein their polluted sewage, even above the improved sources of supply, threaten, ere long, to contaminate or destroy such an enormous supply of what is yet pure and sanitary, if measures be not immediately adopted, indeed, for the prevention of this growing evil—an evil which, by poisoning all large streams, cannot be remedied without a total abandonment of the whole present system of town drainage, and of turning the sewage to some useful instead of deleterious purpose. This, indeed, is the great problem of the day; for while London at this moment can boast of a water supply fully commensurate with the just demands of its mighty population, it is, at the same time, threatened from the drainage, which its abundant supply of water so greatly facilitates, with a pestilential evil, against which it is the imperative duty of every wellwisher for the comfort and health of the greatest metropolis in the world strenuously to combat.

Let us now turn to the water supply, present and prospective, of the French capital, which, among its other late magnificent embellishments, has not been inattentive to the advantages of an improved supply of water.

Paris

is at present supplied with water from various sources. The maintenance of the waterworks and the expense of distributing the water are paid by the municipality. The sources whence the supply are brought are—1st, From the Canal d'Ourcq, by gravitation, which is 52 metres above the level of the sea, and about 20 metres above the lowest point of Paris. 2ndly, From the River Seine, whence it is pumped by steam-engines, and raised to the varied height of 75·30, 72, and 66·24 metres above the level of the sea, and to 43·30, 40, and 34·24 metres above the lowest levels of Paris. 3rdly, From the artesian well of Grenelle, the basin of which is 90 metres above the level of the sea. 4thly, From the aqueduct of Arceuil, the reservoir of which is 57·39 metres above the level of the sea: and 5thly, From sources to the north, which are at much greater elevation, but which in respect of quantity, furnish but little water. The water d'Ourcq is distributed to all the low or less elevated quarters of the city, or

to about two-thirds of the entire surface of the town; the others supply the higher districts. The total length of the principal conduits is 218,213 metres; the length of the smaller pipeage extends to 190,048, or to a total of 408,254 lineal metres, or about 253·6 English miles. The length of the conduits of the water d'Ourque extends to 281,525 metres, while all the others are only 126,729 metres. The whole length of the streets of Paris is about 400,000 metres, which is less than the extent of the pipeage; but there are many streets without water, while there are several with a double pipeage. It would require about 30,000 metres of small pipeage to give water to all the streets of the capital. The daily quantity that can be at present sent into Paris is as follows:—

Water d'Ourque	102,000 metres cube.
„ from Seine	30,000 „
„ from Grenelle	950 „
„ from Arcueil	700 „
„ from Northern sources	200 „
	<hr/>
	133,850
	or about 29,417,000 gallons.

The total quantity distributed varies considerably. During the hot weather of last year the consupt rose to about 120,000 metres cube, viz., from l'Ourque about 100,000 metres cube, and from other sources 20,000 metres cube. In winter the consupt diminished much, but never below 70,000 metres cube. The number of houses within the boundaries of the water supply of Paris amount to upwards of 30,000, of which only 9,936 were, in December, 1857, supplied with pipes, showing that scarcely a third of these receive water directly. The population amounts to 1,093,262, and the number of the houses directly supplied with water being only a third of the whole, it follows that not more than 351,081 persons are enjoying the advantages of water within their houses. Assuming that 120,000 metres cube, or 26,350,000 gallons are sent daily into Paris, and that the population amounts to about 1,100,000, it shows that there is a daily supply afforded of about 24 gallons to each individual inhabitant. The quantity, however, actually used for domestic purposes is, comparatively speaking, small. It has been calculated that the average daily quantity furnished to each house into which pipes are introduced into the court is about 1,444 litres, or very nearly 10 gallons for each inhabitant in such houses. But the average quantity of water furnished to the whole city (one-fifth of the surface of which is above the level of the distributing reservoirs of the several sources) amounts only to 750 litres per day to each house, or to 5½ gallons per individual. It appears, in fact, that between the *fontaines monumentales* and the purposes of trade

and police, about three-fourths of the volume of water is consumed, and that little more than one-fourth is used for domestic purposes. It may be here remarked, that the inhabitants of the French capital have not yet made use of water as an agent for carrying off the impurities of their houses into the sewers which debouch in the river, and consequently the Seine has not yet become, like the Thames, a great *cloaca maxima*, but is still pure—an ornament, and not a nuisance to the city. The peculiar character of the present sewerage of Paris is, that nothing but the rain and waste-water of fountains, or other uncontaminated water, go directly to the Seine, the soil, &c., of houses being run into tanks attached to each building, which are cleaned out at certain times, and carried away to La Valette, beyond the bounds of the city.

It may be supposed strange that in such a city as Paris, where there is water in almost every leading street, and where it is given at a very low price to those who wish it, there should be so few proprietors who take it in. The explanation, however, is very simple, and arises from the following causes:—1st, The rich population continue, as formerly, to take the water for domestic purpose from the carriers of water, drawn from fountains, in which the water of the Seine is carefully filtered, and absolutely refuse to drink the water of the Ourque Canal; while, 2ndly, The poor population avails itself of the 2,000 *bornes fontaines*, or pipes opening in the streets close to the kerb-stone, and of the 69 public fountains scattered throughout the city, whence any quantity of water required may be drawn, free of any cost. It appears that the market fountains, the State and the municipal establishments, consume about 13,000 metres cube; the remainder, or 77,000 metres cube, is expended on the streets and roads, through the *bornes fontaines* and the 69 drawing and 33 monumental fountains, and, lastly, on the Bois de Boulogne, where alone there are not less than 16,000 metres cube expended. In throwing so large a volume of water along the public thoroughfares, and in permitting the drawing of supplies from so many openings, the municipality has not succeeded in the end which they proposed to attain. If these public openings were suppressed the proprietors of houses would each and all be forced to become recipients of water from the city, enabling their tenants thereby to draw water in the courts instead of seeking it in the street, while the streets would be freed from two running gutters which line each of the foot pavements. Up to this moment all the water introduced into houses is drawn from stop-cocks placed in the courts, the proprietors having obstinately refused to distribute it throughout the interior of their property, fearing, as they say, the accidents which might arise from the negligence of their tenants. What the present cost of the water supply of Paris has been, it is difficult to say. Certain of the works have existed for

250 years, while the Canal d'Ourque, which affords the greatest supply, was formed for navigation purposes, for which it is still chiefly used. According to the valuation of M. Belgran, the chief engineer of the present and projected works, we may assume the cost of the existing works at about 20 millions of francs, or 800,000*l.* sterling; and taking the daily quantity of water that is sent into Paris to be 26,350,000 gallons, it follows that for every pound expended there is provided a daily supply of about 33 gallons. To meet the interest of this cost and annual expenditure there is no special tax or forced rate, proprietors being free to take or not as they please the water of the city; but those who take it into their houses pay a very small annual charge. The gross receipts from water paid annually to the municipality in 1857 was only 1,276,550 francs, while there was received from the fountains where the filtered water of the Seine is sold 390 400 francs, or a total of 1,666,950 francs, or 66,680*l.* sterling.

Such is the present state of the Water Supply of Paris; but it is now resolved to alter the whole system, and to bring in a purer and greater supply from the sources of the *Somme-Soude*, by gravitation. Considering that the water is to be brought by aqueducts and conduits from a point between Epernay and Chalons-sur-Marne, in Champagne, a distance of nearly 124 miles, it will not be denied that the project is a bold one, and can only be attained at a vast cost; but under the present energetic Government nothing seems too mighty to be accomplished. The point of departure at the source is 104 metres above the level of the sea; the point of arrival at Paris being 83·50 metres. The size of the circular conduit will be 2 metres in diameter, the length 200 kilometres, and the fall 0·10 per kilometre. The water, to the extent of about 20 millions of gallons per day, on approaching the capital, will flow into the reservoir of Belleville, situated about 200 metres beyond the barrier of Pantón. This reservoir will fill two others, that of Montrouge, situated on the south side of the city, at 80 metres above the level of the sea, and also beyond the barrier, and that of Passy, which is situated on the north-west of the city, at 75 metres above the level of the sea. These three reservoirs will contain together 240,000 cubic metres of water (about 53 millions of gallons), or about 2½ days' supply. The cost of each reservoir will average 1,600,000 francs. The main and small pipeage will be placed in open tunnels for sewerage where these exist, and where they do not they will be laid in the ground. The most elevated positions of Paris, but which occupy a small extent of the city, are 60 to 64 metres, above the level of the sea; the height, however, of the chief portion does not exceed 40 metres; while the greatest height of the houses is 17·50 metres. The water will consequently easily reach the higher flats of the greater part of Paris,

and the lower flat of every house even in its most elevated parts. The contemplated cost of the undertaking, including the expense of the aqueduct, collecting the water, the indemnity to landowners and works, is estimated by the engineer at 26 millions of francs, but the Grand Council of Roads and Bridges have put down the expense at 30 millions, to which the expense of distributing reservoirs and mains, amounting to 17 millions, must be added, making the whole contemplated cost 47 millions of francs, or 1,880,000*l.* sterling. It is proposed that the present pipeage, which is in a very perfect state, should be made use of, and that the water from the Canal d'Ourcq should be reserved for public purposes, but not distributed in greater quantities than at present. It is also proposed that, in order to make use of the 100,000 metres cube easily obtained from this source, additional sewers should be constructed throughout Paris, the half of the streets being only at present furnished with these, which will create an additional expense of 43 millions of francs, or a total cost of 90 millions of francs, or 3,600,000*l.* sterling, for the complete sanitary improvement of Paris. The question necessarily arises how the interest of this large outlay is to be met, and the answer is, by a rate from those taking the water. This, it is apparent, will be considerable, for if we add to the 9,936 proprietors who already pay, the rates paid by public establishments, it will be found that the total number of those taking water from the city is 10,115, which produce, as already stated, 1,276,550 francs; if these receipts be added to the tariff of the water of the Seine, which is very moderate, they will produce at least 2,300,000 francs, which shows the average sum for each ratepayer to be 227 francs, or say 230 francs; and if the 30,000 houses of Paris take the water at this price, the total gross receipts will be 6,900,000 francs, and, deducting therefrom the present receipt of 1,700,000 francs, shows a receipt for the new supply of 5,200,000 francs, which represents about 11 per cent. on the capital (47 millions) employed. It is very probable that every house in Paris will take the new water at a price even higher than that of the filtered water of the Seine. Indeed the rich population will no longer have any objection to urge against the new supply, which will be distributed fresh and clear, and which will be even more agreeable to drink than the filtered water of the Seine. The proprietors also of workmen's houses will be induced to take the water in consequence of—1st, The proposed gradual suspension of all the public fountains, which form a real obstacle to the circulation of the city; 2ndly, By removing the side cocks on the streets, and placing them under the pavements, where the drawing of water would be impracticable for domestic purposes, and which would be likewise more convenient for pedestrians; and 3rdly, By permitting all the ratepayers the liberty

of running their soiled water into the public sewers, which is now collected in tanks attached to each house, and which are emptied at a cost of eight francs per cube metre. The liberty of doing so should, however, only be granted when the proposed great lineal sewers on each side of the Seine are formed to carry off the sewerage of the capital to the country, which will maintain as heretofore the purity and the salubrity of the Seine.

As yet Paris, as we have seen, has not been permitted to make use of the easy agency of water to carry off its impurities into an adjacent river, which has proved such a nuisance and growing difficulty to other large towns; and it is to be hoped, for the best interests of that beautiful capital, that every precaution may be taken, when a more abundant supply tends to induce such a use, to prevent an evil similar to that now experienced in many of our British cities.

Turning from the capitals of England and France to the commercial capital of Germany, we find that

Hamburg

is supplied with water by pumping, and has an average daily supply of 5. Millions of gallons. The population within the bounds of supply is 160,000, which shows a daily supply of $31\frac{1}{4}$ gallons for each inhabitant. The works and distribution are under the charge of the municipality, and the gross cost of them was 170,000*l.*, which gives about $29\frac{1}{2}$ gallons daily for every pound expended. The number of baths and water closets supplied with water amounts to about 6,000. The annual expenditure is paid by the following rates:—1st, For domestic purposes, 2*s.* 6*d.* for every habitable room, kitchen, water closet, or bath within the premises; 2ndly, For every 1,000 gallons used for trading or manufacturing purposes, 6*d.* The soil of the city is collected by a system of sewers, which are discharged considerably below the city, and at ebb-tide.

Leaving Europe, let us next look to the commercial capital of America,

New York.

which is supplied with water from the Croton river, about 40 miles distant, and is brought to the city by aqueducts, upon the principle of gravitation. At the farther point a reservoir has been constructed, the area of which is at least 400 acres, and is capable of containing 500 millions of gallons. From this there is an aqueduct built of stone and brick, 8 feet 5 inches high, and at the bottom 6 feet 7 inches wide, which conveys the water till it reaches the Haarlem river, which is crossed by a stone bridge 1,450 feet long and 114 feet above the tidal flow. From this it is conveyed to a receiving reservoir,

capable of containing 15 millions of gallons, and then to a distributing reservoir, which supplies the city. This undertaking was begun in 1835, by the municipality of New York, and finished at a cost, for the aqueducts alone, and exclusive of the pipe distribution through the town, of about 9 millions of dollars, or 1,800,000*l.* sterling. The pipeage for the supply and distribution of the Croton water from its introduction till the close of 1856 extended to 254 miles 4,490 feet.

In 1849 it only extended to 193 miles, showing an increase in seven years of 61 miles. The pipes employed are from 4 to 48 inches in diameter, viz. :—

48 inches.....	4,087 feet.	12 inches	275,645 feet.
36 „	60,878 „	10 „	5,875 „
30 „	44,862 „	6 „	899,449 „
24 „	5,400 „	4 „	9,472 „
20 „	34,865 „		
16 „	14,083 „	Total	1,854,616

The number of separate dwellings supplied during the year 1857 amounted to 57,458, and the gross quantity supplied per day was 28 millions of gallons. The whole population furnished with water within the boundaries of supply was last year 713,000, which shows nearly 40 gallons per day for each inhabitant; but deducting a sixth for manufactories, leaves for domestic and public purposes, and waste, 32½ gallons for each individual. The number of private shower and plunge baths in New York in 1857 was about 18,813, and the number of water closets, public and private, amounted to 40,209, showing that there existed a bath for every 38 persons, and a water-closet for every 17 persons within the range of supply. Taking the gross cost of the aqueduct works, which amounted to 1,800,000*l.*, and the daily supply at 28 millions of gallons, it follows that for every pound sterling expended there is a daily supply of 15·5 gallons. To meet the interest of the original cost and the annual expense of these waterworks, a compulsory rate, amounting to about 5 per cent., is raised from every building standing upon a street in which a pipe is laid, whether the water be introduced into the house or not; but this rate, from the great fall in fire insurance which has followed the introduction of the Croton water, is little felt, or at least not complained of. The yearly revenue derived from the Croton water during the year of its first introduction was only 84,444 dollars, whereas in 1856 it amounted to 662,949 dollars. The regular rate is from 4 to 100 dollars for each dwelling, but extra charge is made on houses having more than 15 persons residing therein. From this source about two-thirds of the revenue is derived; the other third is raised from manufactories, houses, hotels, refectories, saloons, slaughter-houses, steam-engines, steam-boats, shipping, water-closets, &c.

Perhaps there is no city in the world where in so short a period such an increased consumpt of water has been experienced as in New York. At the first introduction of the Croton stream, it was thought that from this source there would always have been got a sufficient supply to meet every future demand, arising either from an increase of population or of use. But already it appears there is little water to spare, and complaints are also making that the water does not rise in different localities sufficiently high to supply customers who have paid for its use. The cause of this unexpected position of matters arises, not from a want of water to meet all the domestic and other legitimate demands of the inhabitants—for out of the 28 millions of gallons furnished, only 7,500,000 are used in dwelling houses, and 4,500,000 in manufactories—but from the extraordinary waste which has resulted from the first over-abundant supply—a waste which, here as in other cities similarly situated, has begun to be seriously felt, but which it is difficult to control. The truth is, that water has become the easy agent for the removal of much that was formerly and should still be carried away by other means. In consequence of this great waste, it has been already gravely proposed by the Croton Board not to supply elevated buildings and upper storeys of houses with water, believing that here lie the chief sources of excessive consumption and enormous waste, and that the unnecessary consumption in families, hotels, and boarding-houses would not be one-tenth of that which is now committed in those buildings if the policy had been settled at the commencement of the system that service-pipes should not be allowed in such premises above the first storey. It is also stated that the New City Reservoir, about to be commenced, would not have been considered necessary, at so early a period in the history of the waterworks, for the protection of human life and the support of all the great interests of the city, had care been at first taken to prevent this abuse. The only other remedy suggested to diminish this wasteful consumption is the water-meter, and already several of the large establishments are furnished with these measures, and the system it is thought may be in time extended to dwelling houses. In short, with all the supposed endless supply of the Croton Waterworks, the Aqueduct Board, in a late reply to a demand made upon them by the Street Commissioners for the free use of the Croton water, for the purpose of thoroughly cleansing the gutters every night, peremptorily refuses to accede to it, on the ground that sewers are not intended for carrying off the surface filth or deposit, while the expense to the public for thus carrying off what should be carted away would be twenty times as costly as the mere throwing of it into carts from the pavement; and secondly, and chiefly, as they state in their last report, “that “ already the energies of this department are taxed to the utmost to

"keep up a sufficient head in the reservoir to preserve the city from fire and to answer the legitimate demand of the inhabitants. It is indisputable that we have not a gallon of water for any other purpose than the present to spare!"

If London, Paris, Hamburg, and New York have not been inattentive to obtain a plentiful supply of pure water, it may also be stated that a number of the larger provincial cities and towns of England and Scotland have wisely followed their example. The great waterworks of Manchester, Liverpool, Birmingham, Leeds, Carlisle, &c., fully attest what has been done in the southern portion of the island, while the works of Edinburgh, Aberdeen, Greenock, Paisley, Dundee, and the gigantic undertaking now fast progressing at Glasgow, testify to what has been done and is still doing in the north. With respect to the important English provincial undertakings just mentioned, we shall only allude shortly to those of Manchester, Liverpool, and Leeds. Until very lately

Manchester

may be said to have been ill-supplied with the first element of life. The waterworks, however, designed and executed by Mr. J. F. Bateman, which are now nearly completed, have placed that city in the best possible condition. The water, which is soft and pure, is drawn from a considerable distance, and is brought to the city by gravitation. The management of the works and the distribution of the water is in the hands of the City Corporation. The total daily supply for all purposes is at present about 11 millions of gallons, and the population within the bounds of supply being a little over 500,000, shows about 22 gallons a-day for each inhabitant. The separate dwellings, which are nearly all supplied, are about 100,000. The gross cost of the works is about 1,300,000*l.*, including the purchase of the old company; and when the works are fully completed it is calculated that they will furnish a daily supply of 25 millions of gallons, which shows that for every pound expended there will be a daily supply of nearly 20 gallons. The present supply shows only 8·5 gallons for each pound expended. From the as yet limited number of baths and water closets, the consumpt of water for domestic purposes is comparatively small, while there is a proportionally larger quantity used for trade purposes than in other towns. The supply of water by the Manchester Corporation is of three kinds—1st, That for domestic purposes within the city, for which a compulsory rate is levied; 2ndly, The supply to adjoining districts, in a manner similar to a private company, and for purposes of trade within the city; and 3rdly, The supply to other burghs, &c., such as Salford, where the distribution of water and the collection of the rates are in their own hands.

The supply of water for

Liverpool

is brought from several sources, and is under the charge of the corporation. The average daily supply is 11 millions of gallons, and the population within the bounds of supply, including sailors, being estimated at 500,000, shows 22 gallons for each inhabitant. Of the 11 millions of gallons furnished, it is calculated that 65 per cent. is used for domestic purposes, 27 per cent. for trade, and 10 per cent. for public purposes. There are about 72,000 separate dwellings supplied. The number of baths and water-closets is not exactly known, but the estimate of these has been stated at 6,000. The whole cost of the undertaking, including claims yet outstanding, amounts to 1,640,000*l.*, which shows that for every pound expended there is a daily supply of 7 gallons. As in many other towns, the waste of water in Liverpool is considerable. One of the causes of the waste arises from the introduction of water-closets into cottages. It is not, however, a general practice to wash away ashes and filth of that character through the water-closets or drains, nor by the public sewers. In all cases where property is drained, a branch is carried to the ash-pit, and thus much that is in other towns, where an abundant supply of water prevails, carried into rivers, is carted away.

The chief water supply for the town of

Leeds

is brought from Arthington, about 10 miles distant, where it is pumped into a reservoir, from which it is distributed to the inhabitants. The works and distribution are under the management of the Corporation. The average daily supply at present is about 1,850,000 gallons. The number of separate dwellings supplied in March last was 32,312, the population supplied being about 153,000, or at the rate of 12 gallons per day for each inhabitant. As there is no separate rate for baths, it is impossible to say how many may exist in Leeds, but a few months ago there were 1,061 water-closets. The whole cost of the works up to September, 1857, was 283,871*l.* 2*s.*, which shows that for every pound expended there is a daily supply of about 7 gallons. The receipts for the year 1857 were 17,467*l.*; the expenses, including interest on mortgages, 14,638*l.* There is no compulsory rate in Leeds, the taking or not of water being voluntary. The charge for an unlimited supply to a cottage of 5*l.* a year rent is scarcely more than one penny per week, and to a house under 30*l.* sixpence per week.

With respect to the cities and towns situated in the northern portion of the island, we shall shortly allude to the waterworks of

Edinburgh, Aberdeen, Dundee, Greenock, and Paisley, and conclude with a short account of the present and prospective works at Glasgow.

The supply of water to

Edinburgh

is drawn exclusively from the Pentland Hills and the slopes on the east and north sides, and is brought to the city in four large main pipes by gravitation, and is under the charge of a private company. The average daily supply may be taken at 4,800,000 gallons. The delivery has been as high as 5,760,000, but the drought of the last summer has been so long continued, that for several months past it has been a trifle under 4 millions of gallons. The population within the bounds of supply may be taken at 215,000. A large portion of that number, probably between a third and a fourth, are supplied either from private sources or from the public wells. The persons supplied by payment, do not exceed 160,000. Taking, however, the number of persons within the bounds of supply and the supply itself, we find that there are about 22 gallons for each inhabitant. The gross cost of the undertaking is 456,000*l.*, which shows $10\frac{1}{2}$ gallons for every pound expended. The number of baths and water-closets supplied is not known, as no specified charge is made for these, but they are very numerous. The waste of water from carelessness and abuse is very great, not less than a third of the whole supply being, as is stated, in many instances worse than uselessly wasted. At the present moment, the company is engaged in bringing in an additional supply, which will add, in November next, about 2 millions of gallons to the daily delivery, and which will make the daily supply about 7 millions of gallons, or a daily supply to each inhabitant of $32\frac{1}{2}$ gallons. There are few cities where the consumption of water has increased in a greater ratio to the inhabitants than in Edinburgh; and it is stated, that if the consumption continues to increase as it has done during the last ten years, a similar difficulty will be felt there as elsewhere to meet this perhaps uncalled-for demand.

Aberdeen

draws its supply of water from the river Dee, by pumping. The average daily supply is about 1,200,000 gallons, and the population within the limits of supply being about 65,000, gives $18\frac{1}{2}$ gallons for each inhabitant. The whole cost of the works since their commencement in 1830, has been 50,000*l.*, which shows a daily supply of 24 gallons for every pound expended. The revenue raised for payment of management, interest, and expenses connected with these

works, is chiefly by a rate of 9*d.* per pound on dwelling-houses, and 6*d.* per pound on shops, &c., an additional charge being made of 6*d.* per pound when water is supplied within the premises. The water supply is under the management of the Police Commissioners.

Dundee

is supplied with water from Monikie, about 10 miles distant, by gravitation. The average daily supply is 1,750,000 gallons, and the population supplied is estimated at 96,000, which gives about 18 gallons for each inhabitant. The waterworks are in the hands of a joint stock company, which has expended on them 139,000*l.*, which shows a daily supply of upwards of 12½ gallons for every pound expended. The scale of charges is 1*s.* 2*d.* per pound on dwelling-houses above 6*l.* of rent, while the lowest rate, on houses of 2*l.* rent, is 4*s.* 6*d.* per annum.

Greenock

is supplied by the Shaws Water Company and the Corporation, by gravitation. The average daily supply is, by

Shaws Water Company.....	1,850,000 gallons.
Corporation	262,500 „
	<hr/>
	2,112,500 „

and the population within the limits of supply being 40,000, gives nearly 53 gallons for each inhabitant. The gross cost of the works was about 50,000*l.*, but this sum includes the power of supplying mills, sugar-houses, &c. Assuming, however, this as the cost, it shows that for every pound expended there is a daily supply of 42 gallons. The annual expense is paid by a rate of 1*s.* per pound on the rental of all houses using the water supplied by the Shaws Water Company, and of a small additional rating on the part of the Corporation for the water furnished by them through the public wells. The houses of the poorer class, say of 5*l.* and under, are supplied by the Corporation, all others who have water inside are supplied by the Company. The poorer class may, therefore, be held as taxed at 6*d.* in the pound, and the better classes at 1*s.* for water supply, which is abundant.

Paisley

is supplied with water by gravitation. The average daily supply is 1,021,452 gallons, and the population within the bounds of supply being 48,450, gives 21 gallons for each inhabitant. The gross cost of the undertaking was 60,000*l.*, which shows that for every pound expended there is a daily supply of 17 gallons. The works are in the

hands of the Corporation, and the annual expenditure on them is raised by a domestic rate of 1s. 3d. per pound on all lodgings, by a public rate of 3d. per pound on every description of property, by a special rate for horses, cows, warehouses, &c., and by a meter rate for trade purposes. The whole revenue last year was 5,703*l.* 15*s.*

Previous to the year 1806

Glasgow

was but indifferently provided with water. At that time it depended wholly for its domestic supply on twenty-nine public and a few private draw wells, and on the produce of a suburban spring, which was carted to the city and sold from door to door. About that period a water company was formed, to draw water from the Clyde, and to distribute it through the town; and in a few years thereafter a competing company was established for the same purpose, which in the course of time united, and the amalgamated companies continued to monopolise the whole supply till the establishment, in 1846, of another company, limited to supply the south side of the city, on gravitation principles. For some time the two original companies did their best to meet the growing demands of a growing city; and it will not be denied that, while they succeeded in furnishing quantity, the quality was seriously complained of, while the latter company had only a limited supply to offer, and that confined to scarcely a fourth part of the city. To obviate this state of things, the larger company attempted frequently to obtain powers to draw their supply from a purer source; but being unsuccessful in their endeavours, it was at last determined that the works of both companies should be handed over to the municipality by a parliamentary Act, which at the same time contained powers to that body to bring a pure and abundant supply of the primary necessity of life from Loch Katrine, and which when completed will be one of the best and mightiest hydraulic undertakings in the world.

At present Glasgow is supplied, as we have hinted, from two sources—from the river Clyde by pumping, and from streams collected into reservoirs, on the south side of the city, by gravitation, the nominal power used in pumping being 1,000 horses. The highest houses in the city, which may be stated at 275 feet above the level of the river, are all supplied. The length of pipeage in use for its distribution exceeds 130 miles, exclusive of those places where two sets of pipes yet remain, the result of competing companies. The daily supply within the last two years has ranged from 16,119,000 to 17,301,000 gallons, and the population within the boundaries of supply may be reckoned at 420,000, thus showing a gross daily supply for each inhabitant of 40 gallons; or, deducting one-sixth for trade purposes, leaves, including waste, &c., no less than 33 gallons

for each consumer. During the last 18 years the increase of supply and use of water on the part of the inhabitants has been prodigious, the whole quantity distributed in 1830 being 4,500,000 gallons daily for a population of about 200,000, while at the present day it exceeds 17 millions of gallons per day for a population of 420,000, or twice the quantity per head in less than twenty years. To account in some measure for this great and growing use of water in Glasgow, it may be stated that in 1852, from a careful survey then made, there existed within the boundaries of the city no fewer than 6,138 private plunge and shower baths, and 12,144 water-closets; and as the number of separate dwellings have since that period increased to the extent of at least 10,000, coupled with an increasing demand on the part of householders for these conveniences, it will not be too much to say that Glasgow cannot have less than 8,000 of the former and 16,000 of the latter. The use, indeed, of these luxuries is not confined to the rich and middle classes, but extends even to the houses of the working man whose annual rent is only 5*l.* 5*s.*; and the consequence is that a vast and increasing consumpt of water has taken place, arising, it is to be feared, in too many instances from utter carelessness and waste. The cost of the waterworks at present supplying Glasgow, on the 28th May, 1858, was 651,199*l.*, which shows that for every pound sterling expended there is a daily supply of about 26 gallons. The revenue, which is derived chiefly from a rate, amounted last year to 71,413*l.* The expenditure, including interest on capital, but exclusive of the new works connected with the Loch Katrine supply, amounted to 66,566*l.*

Such is the supply and cost of the existing waterworks of Glasgow, which, although abundant and large, have not deterred its citizens from drawing their future supply of water from a distant and purer source, and upon principles which will not only free them from the expense of pumping, but will at the same time afford a supply to the highest house in the city. The idea of supplying Glasgow from the waters of a Highland lake, free of all contamination, 37 miles distant, was first broached in 1848; but it was reserved for the genius of Mr. J. F. Bateman, the engineer of the Manchester Waterworks, to put the idea into execution. Amid surrounding mountains of micaceous schist, subjected to a great rainfall, and isolated from all population, he found ready prepared a great natural reservoir, almost free of cost, and without danger. The superficial area of this reservoir extends to 114,940,000 square feet, and has a catchment basin of more than 35 square miles, to receive an annual rainfall of about 65 inches, and where the evaporation is so small a minimum product of 60 inches. By slightly raising the exit of Loch Katrine, and with a power of draining down the surface to three feet under its ordinary level, a reserve of 5,028

millions of gallons are obtained, which secures a service of 20 millions of gallons per day for 250 days of drought. The water is to be conveyed by mined tunnels, built tunnels, aqueducts, and pipes. The service reservoir is to be placed about six miles from Glasgow; and from the reservoir the water is to be conveyed by two lines of pipes, 36 inches in diameter. The surface of Loch Katrine is 360 feet above the level of the sea. The mean level of the ground on which the greater part of Glasgow is built is under 50 feet of that level. The average height of the houses may be taken at 50 feet. The extreme height of the ground at various points within the range of the distribution of water is 225 feet above high water, making the extreme height at which the water has to be delivered 275 feet above the level of the sea. The tunnels and conduits for conducting the water from Loch Katrine to Glasgow are capable of carrying 40 millions of gallons a day, but the pipes are at present only laid for 20 millions; but when more water is required the addition of the pipeage portion only will require to be doubled. The cost of these new works is estimated at about 700,000*l.*, and, limiting the supply to 20 millions of gallons, shows that for every pound sterling expended there will be a daily supply of $28\frac{1}{2}$ gallons. As these works are now fast progressing, it is almost certain that the whole will be completed early in 1860. When that occurs the daily water supply will be as follows:—

From the Clyde	13,000,000
„ Gorbals	4,000,000
„ Loch Katrine	20,000,000
In all	37,000,000

but dispensing, as is proposed, with the Clyde supply, and thus getting rid of the expense of pumping, there will still remain 24 millions of gallons per day, with a power of increasing it by gravitation to 44 millions. With such a mighty store, it seems almost absurd to suppose that under any circumstances the supply should not be able to meet the demand; but when we recollect the wonderful increase of population which has taken place in Glasgow since the commencement of the century—an increase from 70,000 to 420,000—and the still more wonderful increase in the ratio of the consumption to the population, we do not think it at all improbable that Glasgow may feel ere many years, as New York does now, that she has not a gallon to spare.

Such is the amount of the Water Supply, and its cost, for the several Cities and Towns we have mentioned, and which we now place in a tabulated form for reference:—

WATER SUPPLY to GREAT TOWNS as under.—SUMMARY of RESULTS.

Towns.	Population within Bounds of Supply.	Daily Supply.	Daily Supply for each Inhabitant.	Cost of Undertaking.	Daily Supply for every £ Expended.	Prospective Supply Daily in Addition.
		Gallons.	Gallons.	£	Gallons.	Gallons.
London	2,666,917	81,025,842	30·3	7,102,823	11·4
Paris	1,100,000	26,350,000	24·	800,000*	33·	20,000,000
Hamburg	160,000	5,000,000	31·25	170,000	29·50
New York	713,000	28,000,000	39·27	1,800,000	15·5
Manchester	500,000	11,000,000	22·	1,300,000	8·5	14,000,000
Liverpool	500,000	11,000,000	22·	1,640,000	7·
Leeds	153,000	1,850,000	12·	283,871	7·
Edinburgh	215,000	4,800,000	22·3	456,000	10·5	2,000,000
Aberdeen	65,000	1,200,000	18·4	50,000	24·
Dundee	96,000	1,750,000	18·2	139,000	12·5
Greenock	40,000	2,112,500	52·8	90,000	23·4
Paisley	48,450	1,021,452	21·	60,000	17·
Glasgow	420,000	16,710,000	39·8	651,199	26·	20,000,000

* Independent of the cost of Canal de l'Ourcq.

And now, in conclusion, let me state that, from the statistical figures just given connected with the water supply to great towns, the following results may be drawn:—

1st. The fact of a present prevailing anxiety for an abundant and pure supply of water, irrespective of every difficulty, and at any cost.

2nd. The fact of a growing consumption of water on the part of those who have had it at command, and the necessity of limiting as far as possible the quantity allowed to run to waste.

3rd. That while the increasing abundance of water has necessarily added to the comfort and health of the people, by enabling them to have baths and other conveniences easily and cheaply, it has at the same time tended to encourage city and house impurities being improperly carried away, and that too in a manner calculated rather to *transfer* than to abolish nuisance.

4th. That an abundance of water brought within every house, without due attention being paid to the carrying off to a distance or otherwise separating the solid sewage from the water before it falls into any stream, *is a serious and growing evil*, which ought to be forthwith remedied, particularly on the part of those towns and villages which line rivers from which other towns are deriving their supply of water; and,

5th. That an abundant supply of water is, in short, a limited benefit, except provision be at the same time made for a perfect and profitable riddance of the increased sewage which it invariably creates.